Zuin and Borgonove *Braz J Sci Technol (2016) 3:7*
DOI 10.1186/s40552-016-0020-9

Brazilian Journal of Science and Technology
a SpringerOpen Journal

RESEARCH Open Access

Environmental education in distance learning in Environmental Engineering at Federal University of São Carlos, Brazil: potentialities and limitations towards a critical techno-scientific education

Vânia Gomes Zuin* and Carolina Motta Borgonove

*Correspondence:
vaniaz@ufscar.br
Federal University of São Carlos, (UFSCar), Rodovia Washington Luís, km 235 - SP-310 (Campus São Carlos), São Carlos, SP CEP 13565-905, Brazil

Abstract

Incorporating Environmental Education (EE) in Higher Education Institutions syllabi has been a great challenge for educators. Despite of its importance and the diversity of didactic approaches to build sustainability knowledge and skills in Higher Education, there is a lack in the literature related to the role of Distance Learning (DL) in this process, especially in engineering programs. In this context, the article presents a case study aiming at analising the potential of an EE module to promote critical educational processes in environmental engineering undergraduate course via DL at Federal University of São Carlos (UFSCar), São Paulo state, Brazil. More specifically, the potentialities and limitations of a module in the formative processes of environmental engineers have been analysed, taking into account their views about sustainability and EE concepts based on the Critical Theory. The methodology of this case study research consisted of the analysis content, employing the assessment activities of the students along and at the end of the module, as well as the application of their concepts in a social-educational intervention project. The results pointed out that even though a single module may not be considered responsible for a complete critical EE, there are significant contributions of such DL approach for the understanding of environmental engineering as an ample, critical and participative process by the students of the undergraduate course, specially to enable insights on the deepest causes of the socio-environmental crisis and on the complexity which involves the proposals to change such reality.

Keywords: Environmental education (EE), Distance learning (DL), Environmental engineering, Sustainability in higher education, Critical theory

Background

The inclusion of concepts related to sustainable development, techno-science and the socio-environmental crisis in the curricula of Higher Education Institutions (HEI) has fundamental meaning since the training of the most diverse professionals, who shall be in direct contact with those issues, takes place in this level of education (Brandli et al.

2014). Despite of the widespread expansion and use of information and communication technologies (ICTs) mainly in the last 20 years (Caird and Lane 2015), a relatively limited number of studies on the role of Distance Learning (DL) and Environmental Education (EE) is described in the literature, as can be seen in Fig. 1. A total of 78 articles have been published since 1996, with an increasing trend along the years (ISIS Web of Knowledge; Thomson Reuters). The majority of these articles are related to EE research (31 %), related to the study of specific didactic practices in order to build sustainability literacy. One of the articles that has the highest number of citations (n = 54) examines the impact of social presence on learning in function of the prevalence of computer-mediated communication (CMC) in education (Tu 2000a). Not surprisingly, the successful use of CMC in the classroom requires the selection of the correct medium and group specific instructional design, not replacing face-to-face communication, but provides a more flexible delivery and a greater selection of communication channels for online users (Tu 2000b).

In fact, DL has a history of about two centuries and this time period represents significant changes in how learning takes place and how it is communicated. From writing letters through postal service to the large variety of tools available on the internet, society has embraced new ways and patterns of communication along the years. As computers became more involved in these processes since the 1980's, a proposed definition for DL is the delivery of instructional materials using both print and electronic media, including an instructor who can be physically located in a different place from the learner, as well as possibly providing the instruction at disparate times with diverse forms of materials (Moore et al. 2011).

According to Diamond and Irwin (2013), DL is an important niche to be studied, which can provide effective and imaginative educational ways to embed student sustainability literacy (SL), especially in majors such as engineering, in which the technical training is a preponderant feature. The SL enables someone having the understanding, abilities and attitudes to take informed action for the benefit of themselves and others, presently and into a long-term future.

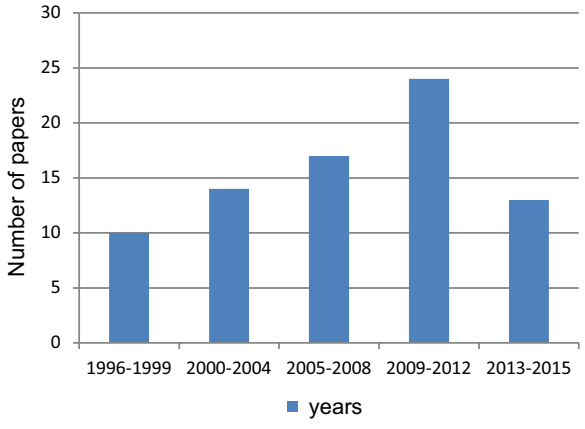

Fig. 1 Number of papers containing the terms "Distance Learning" and "Environmental Education" by ISIS Web of Knowledge (January 1996 to December 2015)

More recently, some initiatives to include green issues using DL and its communication technologies in environmental engineering undergraduate courses have been reported. A program offered by the University of Cincinnati, USA, combining an integrated BS in civil engineering and an MS in environmental engineering with DL extensive practical cooperative education experience was described by Bishop et al. (2004). The authors argue that the result was well-trained graduates who received higher pay and more challenging career opportunities, beyond those from traditional engineering programs. Brenner et al. (2005) analised the simulation of the oxygen-sag model to demonstrate the potential benefits of the application of friendly numerical software packages in environmental engineering education and practice. The use of such software tools (as POLYMATH) encouraged the students to ask open questions.

An approach based on undergraduate student survey methodology by DL at the Department of Process and Environmental Engineering, University of Oulu, Finland, was described by Huuhtanen et al. (2008). *Discendum Optima* was the learning tool developed to conduct online studying and teaching, as a support for campus-lessons and as a web-based environment for DL. The findings were that the students and lecturers see as the main benefits of DL those related to course management, material logistics and the use of new, more illustrative education methods (simulations and animations).

To the best of our knowledge, this is the first study introducing EE via DL in an environmental engineering undergraduate course in Brazil, highlighting the research educational aspects related to the role, possibilities and areas for improvement according to the student´s view. Torres (2002) states that the close relation between engineering field and productive sectors demands that the education of the professionals in these areas fulfill the needs of the market, although the resolution CNE/CES n.11/2002 of the Ministry of Education advocates that the undergraduates at such majors should be able to "(…) develop new technologies, stimulate their critical and creative actions in identifying and resolving problems, considering political, economical, social, environmental and cultural aspects with ethical and humanistic views in order to respond to the needs of the society" (Brazil 2002). This means that the professionals should be educated beyond the technical sphere, which allows them to reflect on the political, economical, social and environmental implications of techno-scientific products in the society, enabling them to act professionally in a more critical manner and coherent with the contemporary needs.

The main mission of the paper is to assess the critical EE effectiveness through DL by a case study conducted at Federal University of São Carlos (UFSCar), Brazil, taking into account the student´s understanding of the sustainability and EE concepts. Thus, the main research question is: which potentialities and limitations has an EE module in a DL environmental engineering undergraduate course toward a critical education according to the students?

The Critical Theory referential adopted in this research brings an important contribution to understanding current society, especially the influence that science and technology dimensions exerts as productive forces, which can promote a scenario of inequalities and socio-environmental degradation (Adorno and Horkeimer 1985; Zuin 2012). Such reality may be understood by the private appropriation of natural resources, which are submitted to the only logic of production. A very elucidative example of this argument is

presented by Maar (1995, p. 15): "What to say of a world in which hunger is overwhelming while, from a scientific-technical point of view, it could have already been eliminated? Or else: how could such a scientifically developed world exhibit so much misery?

Adorno and Horkeimer (1985) understand that the techno-scientific progress not only functions as the main productive force of the system, but also has ideological functions. Science and technology are fetichised, interpreted as objectives in themselves, while nature is understood as a mere resource at the will of human needs. Marcuse (1998) defends that they hold the function of legitimating this system, since they have the promise of well-being and happiness through what they can produce. Therefore, the training engendered by the productive system obeys this logic and aims at the production of adapted students to the detriment of cultural formation, which lead the individual to reflexion and freedom of thoughts.

However, several authors defend the need to develop higher education courses that overcomes that logic and takes into consideration the historic relation between mankind, nature and the values that permeate this relation in current society.

Environmental Education (EE) in its critical current is a questioning alternative of the formative model, which takes to a superficial understanding of the socio-environmental crisis as well as the adoption of scarcely effective proposals for tackling those problems. The so-called technicist EE tends to blame the individuals for environmental problems without questioning the system in which they are inserted and the complex dynamics which determine them (Guimarães 2004). For Loureiro (2012), this facet shows the instrumentalisation of life and supremacy of techno-science and thus perpetuates not only the current system but also human alienation once it praises technique in a non-critical way. The distancing between social theories and environmental matters leads to consolidation of a system that is based on managing natural resources and searching for the resolution of immediate problems without considering the complex relations among science, technology and society in a historically situated manner.

Sauvé (2005) presented a typology of the different practical and theoretical propositions in the form of 15 currents of EE, i.e., general ways of envisioning and practicing them. Some categories have a longer history, as are the cases of naturalist and conservationist currents (more centered on human relationships with nature; centered on resource "conservation," in terms of quantity and quality). For the last one, the main EE programs are based around the classic three R's or those rooted in environmental management concerns (water, waste or energy management).

On the other hand, critical-oriented EE defends that a radical transformation of the relation between the individual and its natural and constructed environment implies in a structural transformation of the society itself, leading to understanding the complexity of such relations and enabling the social actors to intervene in this reality in an adequate and just manner (Loureiro 2012). For Guimarães (2004), a new practice may take place through praxis, i.e., dynamics in which reflexion supports practice, enabling the construction of a new understanding of the world. This movement, in its turn, must be made in a collective participation environment, relating to each other and not isolatedly.

In this paper it is understood that the insertion of critical EE at HEIs corresponds (1) to a curricular environmentalisation encompassing sustainability literacy; (2) which nature is a complex interlinked dynamic system, and life its process of self-organization;

(3) humans are natural beings who can redefine the way of existing in nature by cultural dynamics; (4) human beings are historical and social individuals, multiply constituted; (5) education is a praxis, in a dialogical process of objective and subjective states of reality; (6) social transformation aims at building democratic sustainable societies, which are ecologically prudent, fair, economically feasible and posses cultural diversity (Zuin 2012).

These are the references and principles that guided this research and offered subsidies to investigate the formative processes of the students of the DL in environmental engineering at UFSCar from the EE module. At UFSCar, the target course is offered as DL, having started its activities in September 2007 and with the first group graduated in 2012. This is the first undergraduate course in environmental engineering offered by a public HEI as DL in Brazil, and recently it has been recognised by the council in the area CREA/SP as a model for the registration of new courses as DL (UFSCar 2014). It has the aim of forming a professional who is able to act in conservation, preservation and management of environmental resources, to develop projects to control environmental impacts, to aid in recovering degraded areas and in reforesting projects, besides developing strategies in EE. In order to do that, the student must have a general formation, founded on biology and engineering fields and with strong social and ethical bases (UFSCar 2013).

The 6-year course is composed by a fixed number of core modules divided in 12 semesters, totalising 71 components such as DL, digital literacy, introduction to environmental engineering, Biology, Chemistry, EE being offered in the third semester.

The EE module is the main drive for the humanistic background of this course, and it aims at educating professionals qualified to analyse and diagnose environmental problems, to identify their causes and to adopt preventive and correcting measures facing future risks and environmental damages. The lecturer has the responsibility to plan and prepare the module, continuously coordinate the team of tutors and students and, the tutors in their turn, are in charge of the accompanying and supervising teaching and learning processes of a group with 25–30 students. Therefore, this research aims to analyse the limits of an EE module so that it enables a critical education of undergraduates in DL environmental engineering at UFSCar according to their views, which are consistent with the theoretical and methodological references adopted in this work. A case study was proposed based on the assessment of the writing production of students, their answers for questionnaire surveys and the final intervention project, using analysis content to identify their conceptions about sustainability and EE. A framework of 3 main didactic movements conducted by one of the authors during the application of the EE module, who was also a tutor of 21 students from a total of 195, was proposed as a basis for the present investigation.

Methods

The EE module studied presented themes such as socio-environmental crises and its correlation with the current productive system, dimensions and aspects of EE historically situated, environmental perception and methodologies for the work in EE. This content is approached during 10 weeks, in a total of 60 h of activities, which are developed both in virtual and face-to-face environments.

For all units, several instructional resources, such as video-classes, interviews, web-conferences as well as activities in different formats, such as individual and collective text constructions, questionnaires and forums have been used so that they enrich formative experiences. At the end of 2013, when the results were collected, 195 students distributed amongst 6 tutors were registered, and only 64 students successfully concluded the module. Of the total, 21 students were part of the e-class tutored by one of the authors, who were the main subjects of this research. Aiming at investigating the limits of this module for educating future environmental engineers in a critical perspective, this research was based on the analysis of their production in 3 distinct moments of the course.

The first moment refers to a questionnaire,[1] which approached the initial reflexion of the students on their conceptions about EE. This questionnaire was given to the students before they had any contact with the study references of the module, pointing out questions on the techno-science, environmental crisis and on the role of EE in this context, as well as on the contribution of the module for their professional practice. The questionnaire was composed of statements in which the students could agree or disagree, and justify their arguments. The categorisation of the obtained answers was made from the observation of emerging categories that permitted to identify the manifestation of subjectivities of the participants. The activities of those 21 students were analysed, as mentioned before. As example of activity, the production of individual and collective texts after watching a video-class about consumerism was proposed, within the topic EE and conscient consumption.

In the second movement of the research, the production of the same students observed in the previous moment was analysed, in a reflexion activity based on the same answers given to the first questionnaire. In this activity, the students were supposed to answer if they would modify or keep their initial positions after having studied the main subjects of EE, environmental crisis, production and consumption, conceptions of sustainability, sustainable development and educational practices in EE.

The third moment of the research consisted of the analysis and elaboration of a project of a social educational intervention by the students, which played the role of the concluding evaluation of the module. The concepts, more specifically for EE's approaches, environmental perceptions and participative methodologies, reflected the posture of the student groups in elaborating those projects, were analysed.

This task was carried out in groups of approximately four students, in order to simulate a professional intervention in an actual scenario (company, public and/or private education institution, neighborhood, community), which needed social educational intervention aiming to improve the relation of the subjects involved in their environment. Although such evaluation did not predict that the project should be implemented in practice, the orientation given was that it had all the necessary requirements for that.

The work groups were oriented so that they could provide exchange of experiences about the EE contents learnt, as well as exercising the dialogue among the members

[1] Do you have any previous experience in EE?[1] Regarding a series of statements presented during the discussion, do you agree, disagree or partially agree? Please, justify your answer.[1] Which are your expectations related to the EE module? What would you like to discuss or read?[1] According to you, why you do you need EE?[1] Based on the references studied, which are the currents in EE? Is it possible to identify some of them in our activities or other materials provided or produced by you and your colleagues? Have you changed any aspect of your perception about the role of EE and sustainability?

of the team. However, due to communication problems among the students mainly because of the distance in relation to their poles and time available to arrange a meeting, some projects were carried out individually. The analyses of the projects permitted their classification in categories according to the developed themes and the relations with the studied concepts.

The present research is classified as qualitative, as it focuses on an interpretative understanding of the facts, based on the perspective of involved individuals. In this way, it is also classified as a case study, whose value is in the opportunity to get to know in details a specific reality (Triviños 1987). This was possible due to the proximity of one of the authors with the context of the research, who followed all the educational activities of the students, elaborated feedbacks, discussed and cleared doubts. The study of all texts produced by the students was based on the content analysis method (Puglisi and Franco 2005), and aimed at researching the significance of messages and its understanding, by defined or emerged categories, in this case, some known EE currents (Sauvé 2005; Loureiro 2012; Zuin 2012). The criteria for the identification and classification of parts of student responses in categories were given by a set of common properties which are necessary and sufficient for category membership, qualitatively understanding the phenomenon beyond the data (Bardin 1977).

Results and discussion

As the result of the first moment of qualitative analysis (questionnaire on the initial concepts of the students), a predominance of a normative, disciplinary and behavioural view of EE was found (59 answers), and the critical/emancipatory view of EE did not show that much adherence among the students (25 answers).

These results were expected, since many students hold conceptions that are frequently related to superficial information, as the ones commonly broadcasted in the media (Zuin and Zuin 2011). Besides, education as a way to transmit knowledge reflects the paradigm of human society which privileges the conceptual aspect in the pedagogical process without relating it to other procedural and attitudinal contents, it is believed that the acquisition of conceptual knowledge will only make the individual understand the environmental issues, thus transforming their behavior and society (Guimarães 2004; Sjostrom et al. 2016).

In the second moment, the analyses concentrated on the answers of the students about the initial concepts presented in the first questionnaire; in fact, these two steps are intrinsically linked, since they have the opportunity to revisit their thoughts and arguments. A significant number of students changed their initial positions on the studied topics (13 occurrences), toward a more complex thinking, as expressed by one of them:

> *I used to relate awareness directly with EE and attributed to it the responsibility to develop environmental awareness of a citizen. Besides, I considered the idea that this awareness should come from financial penalties, i.e., it should "hurt the pocket" [financial liability]. So that the individual would develop such awareness positive. Now. I can notice that EE can supply subsides for the education and better prepare the society; however, awareness is individual and should be developed by moral and ethical means and not through penalties. (JA, student of the DL environmental engineering at UFSCar).*

It was possible to observe that some initial concepts were reconsidered, enabling reflexion upon them from the formative experiences provided by the module. According to Zuin (2012, p. 55):

> *(...) is based upon obtaining knowledge which remains in the conscience once the individuals feel touched and sensitive to reform their own practice according to the apprehended concept (...).*

There were also some students who did not present statements related to a reflexive process on the presented questions or who kept their initial positions:

> *I haven't changed my conceptions, because I believe that some of them are the same presented before in the module. I believe people need to be aware of the causes of environmental issues and if each person does their part, everyone will contribute to improving the environment; as the saying: what would be of the ocean if there were not drops (M, student of the DL environmental engineering at UFSCar).*

It is understood that the formative process happens in a very particular way and it is related to the previous experiences of each student. It is important to highlight, however, that the students did not strongly attain to theoretical models so that they would bind themselves considering the models as the universal key to thinking and acting. Therefore, it is believed that the EE module offered elements and opportunities so that the reflexive process could happen, enabling the students to take a position in an aware and adequate way, modifying their thinking and daily practices whenever possible.

In the last phase of the research, analyses of the EE projects elaborated by the students, in a total of 10 projects, 8 of them developed in groups (G1 to G8) and 2 developed individually (D1 and D2) were carried out. From these analyses, the following categories were defined (Table 1):

Categories defined and emerged from the *corpus* of the research, according their characteristics and occurrences.

The criteria for the classification of the projects in the critical/conservationist EE current was the declaration of the authors themselves, once this option reflected effectively the objectives and methodology described in their action plans. In the case of absence of manifestation of the group or student in this matter, the project was classified from evidence presented, i.e. the arguments, the appropriation of theoretical references, the

Table 1 Analysis of the projects developed by the students

Categories	Characteristics
1. Consolidated critical EE	Aligning with the *critical EE*, presenting concepts that are coherent with this facet as well as with the proposed practical activities, e.g., organic garden, food waste control (D1, G1, G5 and G7)
2. Transition critical/conservationist EE	Focus on transmitting knowledge, incorporating *participative and reflexive methodologies* in order to promote behavioural changes (G3, G4, G6)
3. Critical EE in construction	The project proposes activities that are aligned with the *critical EE*, but presented *conceptual mistakes* (G2)
4. Predominantly conservationist EE	The project proposes activities that are articulated with *behavioural/ conservative* (D2, G8)

objectives and methodological procedures. Following are the detailed categories that emerged from the research:

Consolidated critical EE

In this category are the projects whose themes and actions incorporated EE in its critical/emancipatory model more expressively. The developed themes are diverse and refer to reforestation of public areas, building organic vegetable gardens, structuring selective food waste collection and orientation as for ecotoxicologic-friendly consumption. In common, all projects consider the collective participation of the community in a dialogical way to promote EE, as can be seen in some of the illustrative passages below:

> *(…) for everybody to have access to food it would be necessary to create new paradigms which are different from the actual system, changing the anthropocentric conception to cosmocentric, and therefore altering the notion of success and development (D1 project).*

In this example, the project proposes the construction of organic gardens near the community, which brings a great identification with critical EE, especially because it treats this topic as an alternative to the current predatory and excluding model of food production. There is also coherence between the methodological procedures regarding their participative character:

> *Firstly, it is necessary to establish partnerships with institutions in the region that are involved with environmental and community movements aiming to strengthen the project and make it real, besides promoting exchange of ideas and knowledge (D1 project).*

There was also the concern in the following project, whose proposal is to work with the recovery and conservation of degraded areas and riparian zones with the participation of residents of the area, intending to arise reflexion on the matter and demanding environmental preservation to the government.

> *In this case, it is expected an effective participation of the students in terms of cognitive or intellectual contribution, positioning in matters of values or collective participation aimed at solving community problems (G7 project).*

For Loureiro (2005), the educational actions based on Critical Theory are mostly of participative character in which the different social groups that compose a specific institution are invited to participate in the project, program or action. They also involve the collective capacity to identify and resolve problems, stimulating participants to relate their environmental problems with social context in which they are thus forming critical individual conscience of society and social relations.

The works that were classified in the first category had a concern with the social context and the involvement of the community with common characteristics, clearly with the understanding and application of concepts brought by emancipatory/critical EE.

Transition conservationist/critical EE

The projects classified in this category demonstrate understanding and application of the critical EE concepts but showed stronger focus on the individual behavioral changes, especially the ones related to selective recycling and collectioning in several contexts and reduction of waste.

In the following examples, the students developed EE projects on waste in different groups. In both cases, the activities of the project were related to behavioral EE, but there were methodological procedures that explore the dialogue among the participants and the awakening of values from the contact with the environment (e.g., collective reading of references about 3Rs and talking circles):

> *The activities proposed aim the change in behavior of knowledge (about recycling) in a specific area. In this context it promotes the awareness of the involved people, which motivates the search for common interest through simple, but systematised and daily rethought measures (G3 project).*
> *Therefore, this project is based on active participation of the participant public, and aims at understanding their conceptions, experiences, knowledge, feelings and working their cultural roots for the change of values and attitudes (G6 project).*

It is possible to observe in these passages elements both of conservationist EE (inform, dictate adequate behaviour) and of critical EE (active participation of the target public, understanding their conceptions, exchange of experiences). In this dialectic movement, Adorno states that "(…) teaching should not consist only in choosing what is right, and in doing so through categories but from the beginning, teaching should develop critical aptitudes" (1995, p. 79–80). In other words, the educational processes should "lead people to the ability of uncovering ideologies", enabling them to think critically on the concepts and to acquire independent and autonomous judgment about them.

Critical EE in construction

Projects emphasising collective action organised to find solutions to problems as well as proposals of actions consistent with this current, but that did not present a coherent argument and, in some cases, showing conceptual mistakes were classified in this category.

In the following project, which the main objective was to work with the recovery of degraded areas of an aquatic park, it is clear the inconsistency between the position of the group, in favor of a critical EE, and its proposals of actions:

> *The action must be taken by the local population, as they already know well the park and its rich diversity and exchange experiences and renew the ideas collectively. It is observed that "raise awareness" has become a common sense expression, as if awareness needed to be purchased as something external to the human being." (G2 project).*
> *The project aims to insert new concepts of conservation to visitors and residents of the area surrounding the "Parque Aquático", located in the city of Sorocaba, São Paulo, in order to avoid damage and protect local biodiversity. Everyone will have the opportunity to follow volunteer monitors who know and have experience in the park so that they can share experiences and show the need to preserve the park sim-*

ply and objectively, highlighting its usefulness and importance to the existing biodiversity (G2 project).

In this example it is possible to observe that while the group understands that "making people aware" is a process that is external to the individual and is not consistent with the proposal of the project, this ends up being its strategy of action, through "demonstrating" the importance and usefulness of "environmental conservation".

Conservationist EE

In this category, projects are characterised by the proposals that showed no reflexion on the more contemporary trends on EE and their significance for educational practices, presenting conceptual incoherences and actions that do not consider the complexity of addressed contexts.

In the following example, the objective of the project focuses primarily on transferring knowledge that is aimed at modifying attitudes. In the passage the belief in the acquisition of knowledge as a necessary and practically single condition is stressed, in order to acquire an environmental awareness:

Many students, either because of lack of culture or lack of examples at home, feel difficultly to get oriented or build an aware knowledge, in terms of environmental education. However, they present some obstacles created by ignorance on such areas of knowledge. Offering orientations to the students and helping them to build a knowledge that orient them towards a model of consumption and disposal of solid residue that have the least possible impact (D2, tutor A).

In this example, there seems to be a belief in an almost mathematical equation that the sum of a great number of approached concepts would result in actions and behaviors that are "correctly" mandatory (Zuin 2012).

According to Leme (2008), the main feature of this type of EE is its role as a diffuser of knowledge about the environment and a catalyst in the replacement of habits and behaviors that are considered predatory by other more sustainable ones. In this respect, it is postulated that the lack of knowledge about the environment is responsible for destructive attitudes, which is evident in these projects.

In the projects placed in categories 1 and 2, there is a predominance of arguments and proposals for activities that are consistent with critical EE. In category 3, there was reference to EE as a collective and political participative practice, translated into activity proposals, but with conceptual errors. In these cases, there are positions that are different from those presented by most students in their initial conceptions. This was seen from the comparative analysis of the three moments analysed, in which it could be observed that 14 students out of 21, presented final projects in which the concepts of critical EE and sustainability were considered in their proposals, although they presented different conditions of appropriation of these concepts and their articulation with the approached contexts.

Only in category 4 it was observed that the proposals of the projects were not closely related to the concepts studied, and, in some cases, they presented ideas much closer to common sense than to reflexions consistent with the desired critical education. It can be said that in these cases the formative experience fell short of the formation module

sought to provide, based on the theoretical reference adopted in this research when considering the critical and emancipative perspective of the educational processes (Adorno 1995; Zuin 2012).

However, it is understood that even in this case, it is not possible to classify the production of these students as a result of semi-formation. According to Adorno (1995), it would be a result of the assimilation of superficial and ephemeral contents, engendering adaptation to society and its current production. Neuvald and Guilhermeti (2006) add that the semi-formation occurs from grasping the contents as if they were things, unrelated to social relations that engender them. In the specific case of the production of these students, it is not possible to say that they were the result of this type of formation, or that they were related to the conditions offered by the EE module. This scenario should be understood within a broader context that takes into account the different situations experienced by students, i.e., matters that are also external issues to the condition of students in DL environmental engineering, as is the case of their previous experiences before the HE, the contents learnt in other spaces at UFSCar (attending events as summer schools, participating in research projects, non-academic activities etc).

In this sense, from the obtained data it can be inferred that the reflexive learning provided by the didactic activities developed during the module was considered significant for the promotion of a critical EE by most students.

Conclusions

The objective of this qualitative case study was to analyse the contributions of the EE module for the education of students via DL in environmental engineering at UFSCar, specifically in relation to the critical formation processes, perceived as the ability to understand environmental crisis in their broadest aspects: techno-scientific, historical, political, economical, social and cultural dimensions. It also sought to investigate if the students were able to organise and apply such knowledge in elaborating an EE project, simulating a situation that will be experienced by the students in their professional life.

From the analysis of the productions of the students along the module, it was possible to observe that it offered significant contribution for a humanistic, ethical and critical education to the students at the environmental engineer course investigated. This evidence may be observed by the obtained results, which showed that in the beginning of the course, a more normative and disciplinary view of EE was predominant while, at the end, there was a considerable change in the posture of the students in relation to their initial concepts, which could be observed by the projects of social-educational interventions presented. Among the 10 projects, 7 presented evidence of critical understanding of the studied concepts in different levels of appropriation (categories 1 and 2).

Despite these results, it is appropriate to point out that the EE module could not be considered as the only possibility to reach the desired critical education, considering that there are several forces that enable the individuals and groups to reflect on matters that crucially affect their lives. Therefore, it is important to point out that nobody is completely emancipated from the social political context where they came from (Kincheloe and McLaren 2006). Thus, the resistance of the students to incorporating new contents with a more critical and deeper view on sustainability can occur due to the different degrees of positioning considering the reality, which can come from existing

experiences that they have, which were consolidated as a reference to them (e.g., 3Rs programs, reforesting).

However, even with the presented difficulties related to the novelty of the DL approach (for instance, the intervention project that should be written by a group instead of just 1 student, the drop out of the students from the undergraduate course and this studied module), it is possible to observe that the majority of the students were able to broaden their initial concepts on EE, understanding and applying concepts related to a critical and participative praxis. These are indispensable to a more humanistic and reflexive practice, which is also more attentive to the complexities of social-environmental matters and aiming at the promotion of a development integrating society, environment and technical-scientific knowledge, which then results in a better quality of life, especially in Brazil.

Authors' contributions

All authors participate in the research conception as well as the theoretical and methodological choices. CB collected and analysed preliminary the data, which were reviewed by VGZ. Both authors read and approved the final manuscript.

Authors' information

Borgonove is PhD student under the supervision of Prof. Zuin in the Postgraduate Program in Education (PPGE) at UFSCar. Both of them have experience in theoretical and practical aspects on Education in Sustainability, with complementary profiles. Prof. Zuin´s background is Analytical Green Chemistry and Green Chemistry Education, mainly focusing on the development and dissemination of Green Chemistry educational material for Higher Education.

Acknowledgements

The authors thank the PPGE-UFSCar, CAPES and CNPq (311000/2014-2) for their important support.

Competing interests

The authors declare that they have no financial competing interests and non-financial competing interests (political, personal, religious, ideological, academic, intellectual, commercial or any other) in relation to this manuscript.

Received: 31 December 2015 Accepted: 26 February 2016
Published online: 14 March 2016

References

Adorno TW (1995) Educação e Emancipação. Paz e Terra, Rio de Janeiro
Adorno TW, Horkeimer M (1985) Dialética do esclarecimento: fragmentos filosóficos. Jorge Zahar, Rio de Janeiro
Bardin L (1977) Análise de conteúdo. Edições 70, Lisboa
Bishop PL, Keener TC, Kukreti AR, Kowel ST (2004) The ACCEND program: a combined BS and MS program in environmental engineering that includes co-operative work experience. Water Sci Technol 49:73–79
Brandli et al (2014) Evaluation of sustainability using the AISHE Instrument: case study in a Brazilian University. Braz J Sci Technol 1:4. doi:10.1186/2196-288X-1-4
Brazil, Ministry of Education (2002) Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia. http://portal.mec.gov.br/cne/arquivos/pdf/CES112002.pdf. Accessed 15 Jan 2016
Brenner A, Shacham M, Cutlip MB (2005) Applications of mathematical software packages for modelling and simulations in environmental engineering education. Environ Modell Softw 20:1307–1313. doi:10.1016/j.envsoft.2004.09.007
Caird S, Lane A (2015) Conceptualising the role of information and communication technologies in the design of higher education teaching models used in the UK. Br J Educ Technol 46:58–70. doi:10.1111/bjet.12123
Diamond S, Irwin B (2013) Using e-learning for student sustainability literacy: framework and review. Int J Sustain High Educ 14:338–348. doi:10.1108/IJSHE-09-2011-0060
Guimarães M (2004), Educação ambiental crítica. In: Layrargues PP (Coord.) Identidades da educação ambiental brasileira, Ministério do Meio Ambiente, Diretoria de Educação Ambiental, Brasília
Huuhtanen M, Yla-Mella J, Jeronen E, Keiski R (2008) A novel approach for undergraduate researcher education in engineering studies. J Balt Sci Educ 7:185–192
Sjostrom J, Eilks I, Zuin VG (2016) Towards eco-reflexive science education: a critical reflection about educational implications of Green Chemistry. Sci Educ. doi:10.1007/s11191-016-9818-6
Kincheloe JL, MClaren P (2006) Pesquisa Qualitativa: teorias e abordagens. Artmed, Porto Alegre
Leme PCS (2008) Formação e atuação de educadores ambientais: análise de um processo educativo na universidade. Universidade Federal de São Carlos, Tese (doutorado)
Loureiro CFB (2005) Teoria Crítica. In. Ferraro-Júnior LA (Coord) Encontros e Caminhos: formação de educadores ambientais e coletivos educadores. Ministério do Meio Ambiente; Secretaria Executiva; Diretoria de Educação Ambiental. Brasília

Loureiro CFB (2012) Teoria social e questão ambiental: pressupostos para uma práxis crítica em educação ambiental. In: Loureiro CFB (ed) Sociedade e meio ambiente: a educação ambiental em debate, 7th edn. Cortez, São Paulo
Maar WL (1995) A guisa de introdução: Adorno e a experiência formativa. In: Maar WL (ed) Educação e Emancipação. Paz e Terra, Rio de Janeiro
Marcuse H (1998) Algumas implicações sociais da tecnologia moderna. In: Kellner D (ed) Tecnologia, cultura e Fascismo. Unesp, São Paulo
Moore JL, Dickson-Deane C, Galyen K (2011) E-learning, online learning, and distance learning environments: Are they the same? Internet High Educ 14:129–135. doi:10.1016/j.iheduc.2010.10.001
Neuvald L, Guilhermeti P (2006) A semiformação no curso de pedagogia: uma reflexão introdutória. http://www.ufsm.br/gpforma/2senafe/PDF/026e4.pdf. Accessed 15 Jan 2016
Puglisi ML, Franco B (2005) Análise de conteúdo. Líber Livro Editora, Brasília
Sauvé L (2005) Currents in environmental education: mapping a complex and evolving pedagogical field. CJEE 10:11–37
Torres SR (2002) A formação de docentes da engenharia e processos de mudança: contribuições para formação de professores. Tese (Doutorado). Pontifícia Universidade Católica de São Paulo, São Paulo
Triviños ANS (1987) Introdução à pesquisa em Ciências Sociais: a pesquisa qualitativa em educação. Atlas, São Paulo
Tu CH (2000a) On-line learning migration: from social learning theory to social presence theory in a CMC environment. J Netw Comput Appl 23:27–37. doi:10.1006/jnca.1999.0099
Tu CH (2000b) Critical examination of factors affecting interaction on CMC. J Netw Comput Appl 23:39–58. doi:10.1006/jnca.1999.0100
Universidade Federal de São Carlos (2013) Pioneira na oferta de curso de Engenharia na modalidade a distância, UFSCar forma sua primeira turma. http://www2.ufscar.br/servicos/noticias.php?idNot=5504. Accessed 15 Jan 2016
Universidade Federal de São Carlos (2014) CREA-SP escolhe curso de Engenharia Ambiental a distância da UFSCar como modelo para novos registros. Secretaria Geral de Educação a Distância Universidade Federal de São Carlos. http://www2.ufscar.br/servicos/noticias.php?idNot=6584. Accessed 15 Jan 2016
Zuin VG, Zuin AAS (2011) Professores, tecnologias digitais e a distração concentrada. Educar em Revista 42:213-228
Zuin VG (2012) Environmental dimension in chemistry teacher education. Alínea, Campinas